

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area From December 1, 2009 to April 7, 2010

By Douglas Heath* and Marcel Belaval**

Received August 24, 2010

Abstract

The Massachusetts Department of Transportation (MassDOT) and the Executive Office of Housing and Economic Development (EOHED) have proposed the I-93 Tri-Town Interchange Project. This project would add two travel lanes and a new break-in access interchange near the Andover, Tewksbury, and Wilmington town borders to alleviate traffic congestion and promote the development of nearly 700 acres in the area. Winter 2009-2010 water-quality monitoring by EPA New England detected chronic and/or acute exceedances of chloride above the aquatic life standards in five of the six perennial streams in the Tri-Town area prior to construction. These exceedances are attributed to tons of deicing chemicals applied on state, municipal, and private roads and parking lots that flow into surface water and infiltrate ground water. In addition, sodium concentrations in municipal water supplies in Andover and Wilmington were six to seven times above the 20 mg/l advisory level for those individuals restricted to a total sodium

intake of 500 mg/day (EPA Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sodium, Feb 2003, EPA 822-R-03-006).

Objectives

Water quality monitoring occurred at nine stations in six streams and one municipal wellfield. We identified and evaluated baseline water-quality concentrations of chloride, sodium and other ions in Martins Brook, Sutton Brook, Shawsheen River, an unnamed Tributary of the Shawsheen River, Pinnacle Brook, Fish Brook in Andover and Wilmington's Brown's Crossing Wellfield during the 2009-2010 winter season. (see Figure 1 for locations of these monitoring stations). This information will provide a baseline against which project-related impacts can be predicted for the proposed project as part of the water-quality analysis being developed for the Draft Environmental Impact Statement under the National Environmental Policy Act (NEPA) by the Massachusetts Department of Transportation and the Federal Highway Administration.

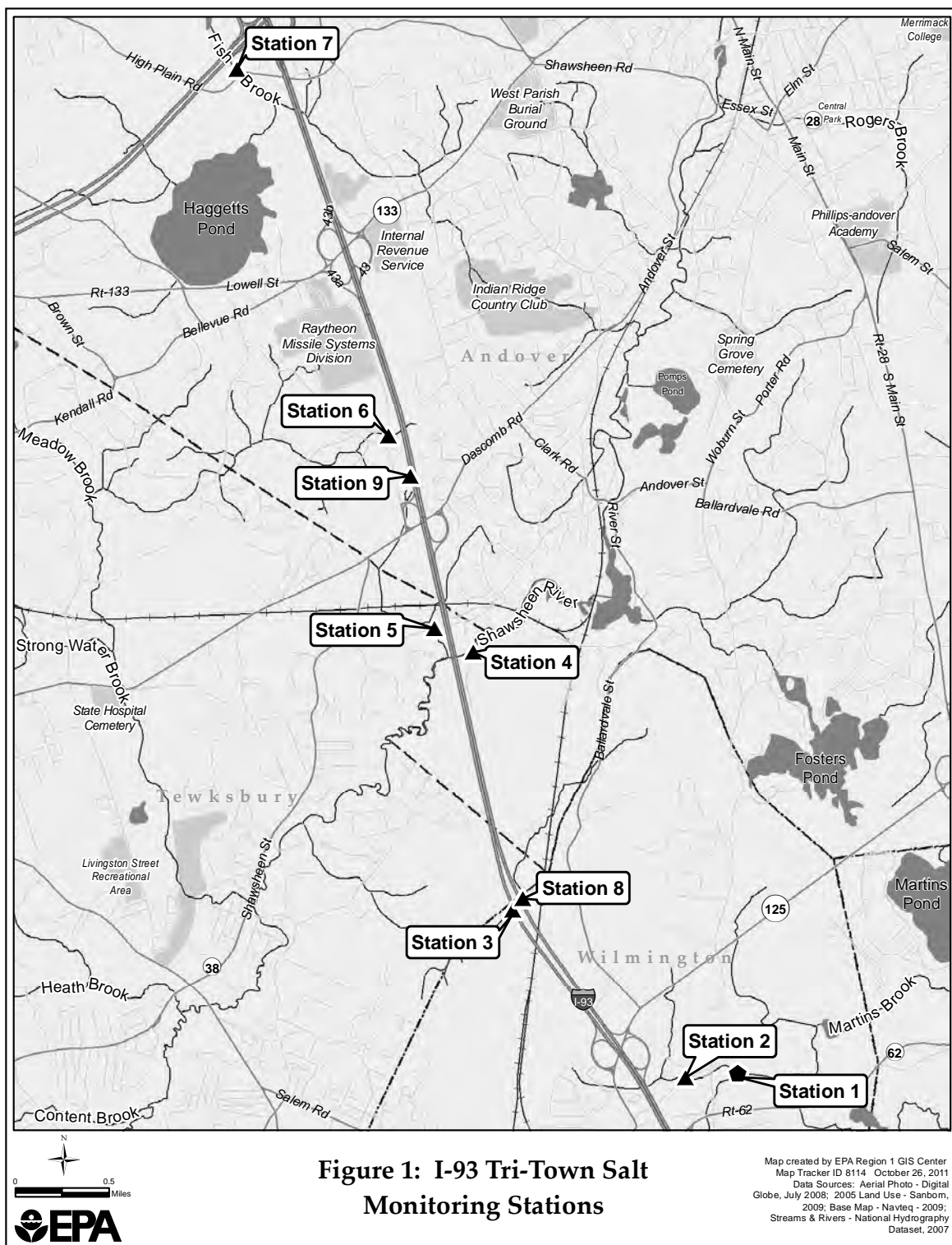
Design, Methods and Participants

This baseline assessment closely followed the monitoring strategy, procedures and equipment that had effectively identified road-salt impacts to streams along I-93 from 2002 to 2006 in southern

*Hydrogeologist, Office of Ecosystem Protection, U.S. Environmental Protection Agency-Region I, Boston, MA

**Hydrogeologist, Office of Ecosystem Protection, U.S. Environmental Protection Agency-Region I, Boston, MA

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010



Douglas Heath and Marcel Belaval

New Hampshire, located only six miles north of the I-93 Tri-Town Project area. For more information regarding data, documents and reports from that study see: <http://www.rebuildingi93.com/content/environmental/waterquality/documents/>.

The Project Work/QA Plan describing sample collection, handling and analysis at seven monitoring stations was approved by EPA on November 4, 2009. When resources permitted, two more stations were later added upstream of Sutton Brook and at an I-93 storm water outfall located approximately 1,300 feet north of Dascomb Road. Water-quality monitoring consisted of biweekly collection of grab samples and field parameters and the deployment of programmable datasondes that measured temperature and specific conductivity at 15-minute intervals. These instruments were attached to concrete blocks and wire tethers, placed on the stream bottom with the sensor facing upstream, and retrieved every 2 to 3 weeks for data retrieval, calibration and cleaning. The datasondes and field meters were also calibrated for specific conductivity at the beginning and end of each deployment using 10,000 uS/cm and 500 uS/cm standards. If the instrument read within 10% of the standard the calibration was considered accurate and the data were retained. In this study, the largest discrepancy between pre-and post-calibration measurements among all eight sondes was 7%.

All water quality data were quality assured using field duplicates and trip blanks for each sampling round. Grab samples were collected in 125-ml bottles, stored on ice and delivered the same day to the EPA Region I New England Office of Environmental Measurement and Evaluation in North Chelmsford, MA. Samples were then analyzed using a Dionex ICS-3000 Ion Chromatograph following the *EPA Region I Standard Operating Procedure ELASOPINGIC11* for common ion analytes.

Water-quality samples were also collected by a graduate student under the supervision of Professor Rudi Hon of Boston College. In addition, William Arcieri of Vanasse Hangen Brustlin, Inc. (VHB), a MassDOT contractor, deployed datasondes and collected samples upstream of I-93 in Pinnacle Brook and an unnamed Tributary of the Shawsheen River from February to April 2010. Field measurements of specific conductivity combined with chloride concentrations from 76 stream samples at Stations 1-8 support a linear regression equation for these streams: Chloride (in mg/l) = $0.2993 \times \text{Specific Conductivity (in uS/cm)} - 25.877$ ($r^2 = 0.99$, $n = 76$). Using this relationship, the chronic and acute chloride standards for aquatic health in surface water (230 and 860 mg/l) are equivalent to specific conductivities of 855 and 2,960 uS/cm, respectively (Figure 2). These values compared favorably with those calculated from a regression equation derived from 649 paired measurements of chloride and specific conductivity collected by EPA New England, NH Department of environmental Services and NH Department of Transportation between 2002 and 2006 along I-93 in southern New Hampshire: Chloride (in mg/l) = $0.307 \times \text{Specific Conductivity (in uS/cm)} - 22$ ($r^2 = 0.97$, $n=649$). For that project, equivalent values of specific conductivity were 833 and 2,886 uS/cm, respectively. Differences in regression relationships may be attributed to watershed variations in ion concentrations due to rock type, proximity to coastal zones, soil characteristics and other factors.

Field measurements and laboratory analyses are provided in Appendix A.

Main Outcome Measure

In 1988, EPA defined chloride toxicity to aquatic life using chronic and acute criteria. Chronic toxicity is expressed as “the 4-day average concentration of chloride, when associated with sodium, does not exceed 230 mg/l more than once every 3 years on average.” Acute chloride toxicity

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

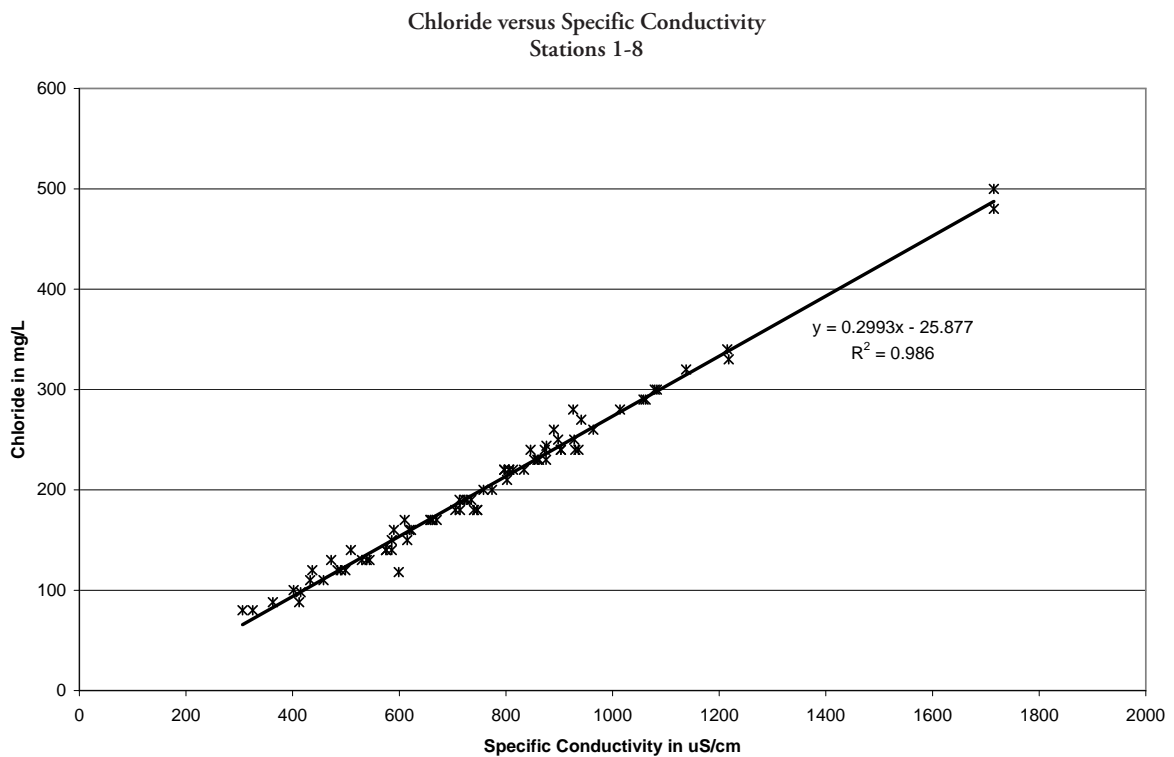


Figure 2: Specific conductivity and chloride regression

is defined using a much briefer time span: “the 1-hour average chloride concentration does not exceed 860 mg/l more than once every three years on average” (*USEPA, February 1988, Ambient Water Quality Criteria for Chloride –1988: Office of Water Regulations and Standards, Criteria and Standards Division, Washington, DC, EPA 440/5-88-001, page 8*).

The datasonde measurements of specific conductivity were then converted to chloride concentrations to determine the number and periods of exceedances of the chronic and acute water quality standards. Chronic and/or acute chloride exceedances were detected in five of the six streams monitored from 12/1/09 to 4/7/10. From south to north, these streams are Martins Brook, Sutton Brook, an unnamed Tributary of the

Shawsheen River, Pinnacle Brook and Fish Brook. No exceedances were detected in the Shawsheen River at I-93. Sodium at the Brown’s Crossing Wellfield in Wilmington ranged from 110 to 140 mg/l. The federal and state advisory level for sodium in drinking water for people under salt-restricted diets is 20 mg/l. Table 1 lists the periods of chloride exceedance, the duration in hours and the maximum chloride concentration detected at individual stations. Figure 3 contains graphs of chloride over the study period at Stations 2 -8 derived from continuous monitoring of specific conductivity. Gaps in portions of the records for Stations 3, 5, 6 and 8 indicate where data was omitted due to several factors, such as sonde burial in stream sediment during flood events, or a sensor filled with organic debris. At Station 5, the datasonde at Vale Street was also washed out of the

Douglas Heath and Marcel Belaval

Table 1. Chloride Water Quality Exceedances

Station	From	To	Exceedance time in hours	Max. Cl Concentration in mg/L	Exceedance Type
2	12/6/2009 2:45	12/10/2009 4:00	96.75	649	Chronic
2	12/16/2009 23:15	12/27/2009 11:30	252.25	377	Chronic
2	12/29/2009 9:45	1/25/2010 16:15	654.5	430	Chronic
2	1/29/2010 6:45	2/24/2010 11:45	628.5	545	Chronic
2	3/7/2010 0:30	3/13/2010 20:45	164.25	268	Chronic
3	12/6/2009 2:00	12/6/2009 7:00	5	1186	Acute
3	12/9/2009 14:15	12/9/2009 16:00	1.75	1278	Acute
3	1/2/2010 12:30	1/2/2010 18:15	5.75	1339	Acute
5	12/5/2009 22:00	12/10/2009 10:30	60.5	1346	Chronic
5	12/17/2009 0:45	12/27/2009 7:15	246.5	418	Chronic
5	12/30/2009 2:00	1/25/2010 15:15	636.25	1151	Chronic
5	2/6/2010 3:30	2/10/2010 9:00	101.5	257	Chronic
5	2/10/2010 14:15	2/14/2010 15:45	97.5	627	Chronic
5	3/7/2010 5:15	3/13/2010 17:15	156	389	Chronic
5	12/6/2009 4:45	12/6/2009 11:30	6.75	1346	Acute
5	12/9/2009 16:15	12/9/2009 18:15	2	1323	Acute
5	1/2/2010 13:15	1/2/2010 21:45	8.5	1151	Acute
5	1/18/2010 16:15	1/18/2010 20:30	4.25	1147	Acute
5	2/17/2010 15:30	2/17/2010 18:00	2.5	985	Acute
6	1/17/2010 21:15	1/25/2010 15:45	186.5	1016	Chronic
6	12/6/2009 4:45	12/6/2009 8:15	3.5	984	Acute
6	12/9/2009 17:30	12/9/2009 19:30	2	1005	Acute
6	1/19/2010 23:15	1/20/2010 2:00	2.75	1016	Acute
7	1/18/2010 20:15	1/25/2010 14:45	162.5	289	Chronic
9	94% OF MONITORING PERIOD		1692	7028	Chronic
9	89% OF MONITORING PERIOD		193.25	7028	Acute
Total chronic exceedances		14	Total hours exceeding chronic levels		5135.5
Total acute exceedances		12	Total hours exceeding acute levels		238

channel early on January 26th due to heavy rains. William Arcieri of VHB, Inc., while doing field work in the area, placed it back in the channel.

Box plots of ions at all stations are shown in Figure 4. Box plots show the distribution characteristics of ion concentrations plotted separately for each sampling station. The median and quartiles (25%-75%) of each ion are computed for each station and are presented in the box plot. Whiskers outside the quartile box show the non-outlier range of concentrations measured. Concentrations which are far from the middle of the distribution are plotted as outliers and extremes, depending on distance from the middle.

Results

Station 1: Brown's Crossing Wellfield in Wilmington, MA

Geographic Setting and Land Uses:

The town of Wilmington has four active ground water sources for public water supply. Of these, Brown's Crossing Wellfield has the largest maximum daily capacity of 1.2 million gallons a day (mgd). The other active drinking water supplies are the Barrows, Salem Street and Shawsheen Avenue Wellfields with daily maximum capacities of 0.94, 1.01 and 0.72 mgd, respectively. A map of the Martins Brook watershed upstream of

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

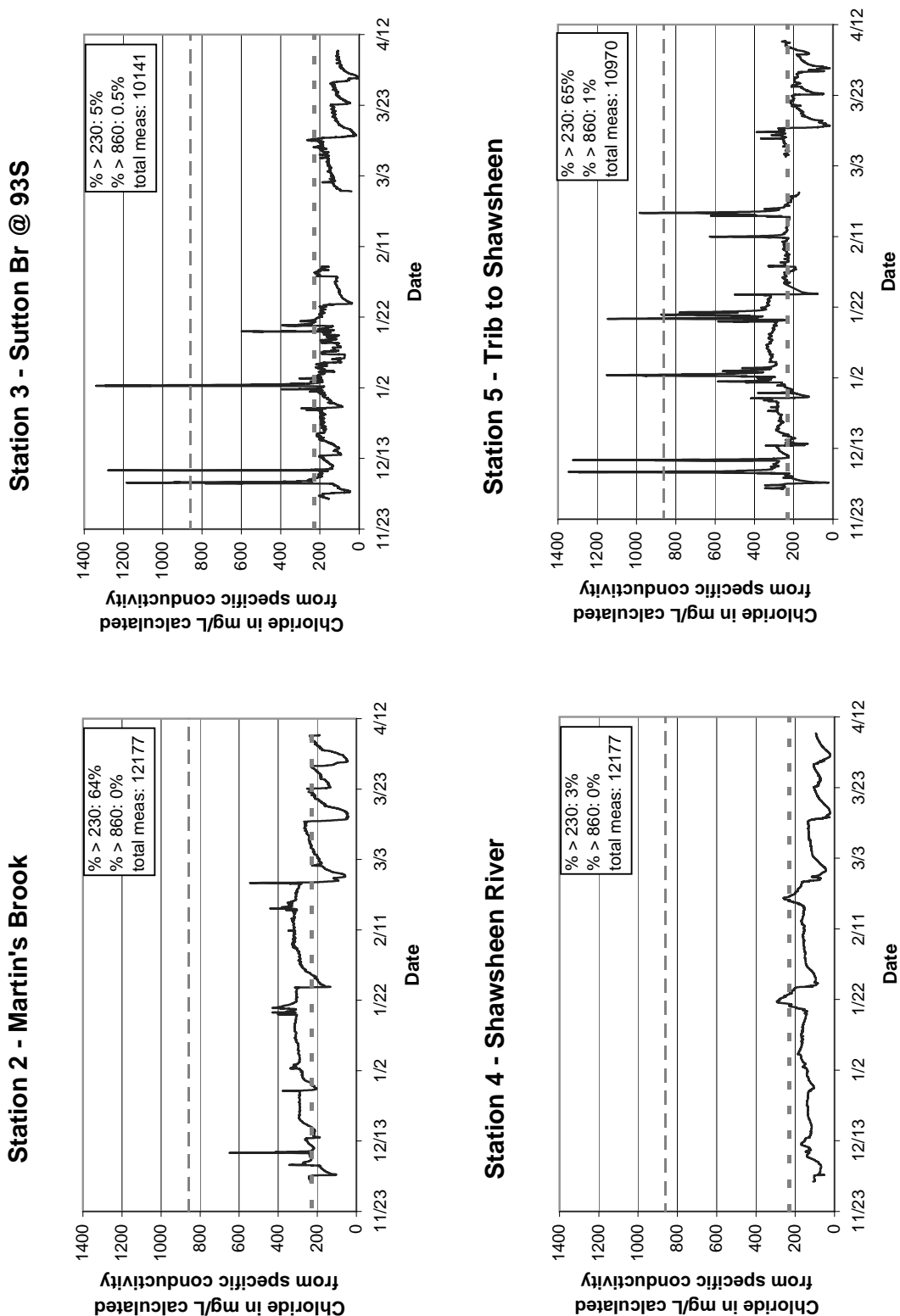
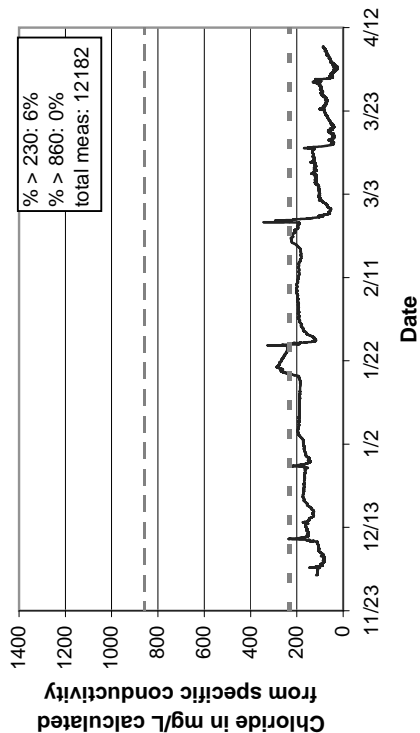
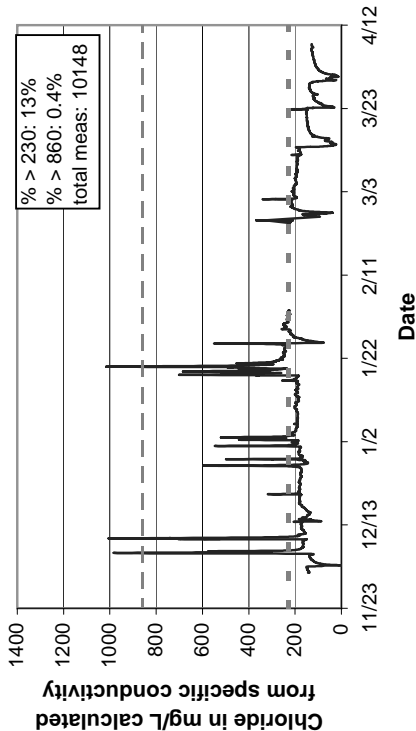


Figure 3: Time series chloride graphs, calculated from specific conductivity. Dashed lines indicate water quality thresholds for chloride (230 mg/L and 860 mg/L).

Station 7 - Fish Brook



Station 6 - Pinnacle Brook



Station 8 - Sutton Br @ 93N

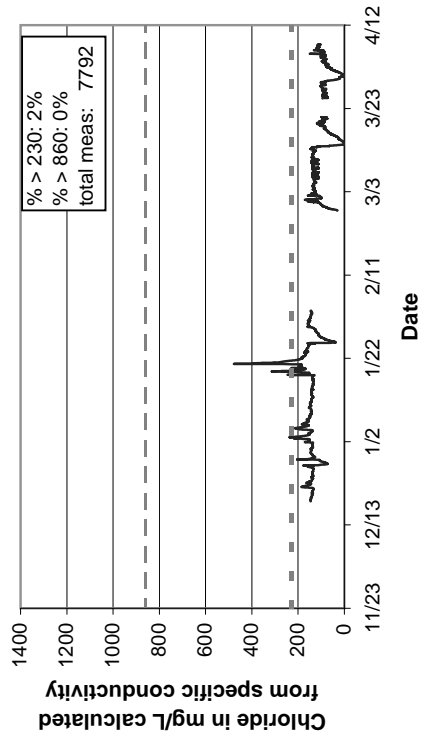


Figure 3: Time series chloride graphs, calculated from specific conductivity. Dashed lines indicate water quality thresholds for chloride (230 mg/L and 860 mg/L).

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

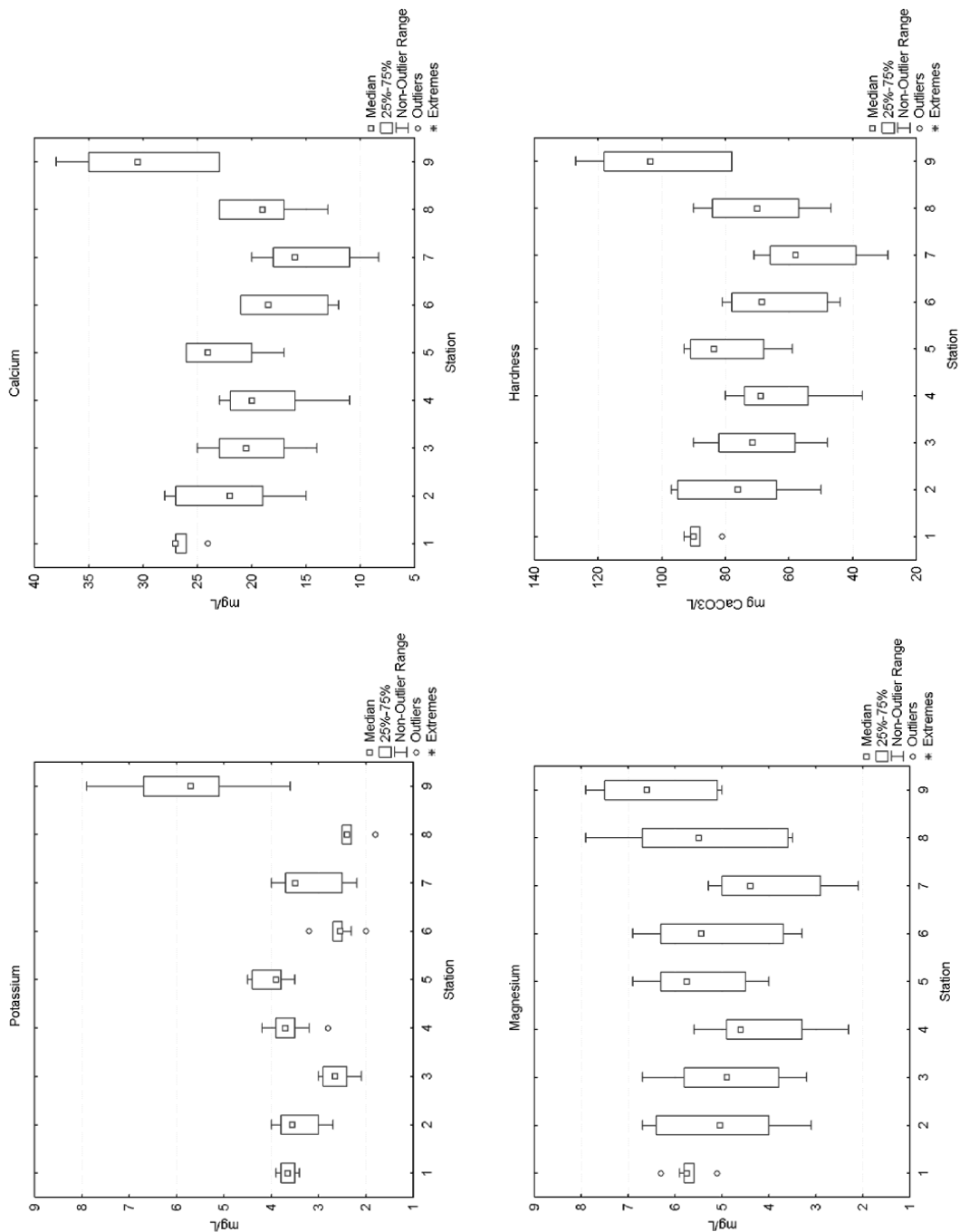


Figure 4. Box plots of ion concentrations. Reporting limit values substituted for non-detects. Br, Fl, and NO₂ not plotted due to high number non-detects (88%, 98%, and 100% non-detects, respectively). Number of samples for each analyte at each station was 10, except for stations 7 (N=9), 8 (N=7), and 9 (N=6).

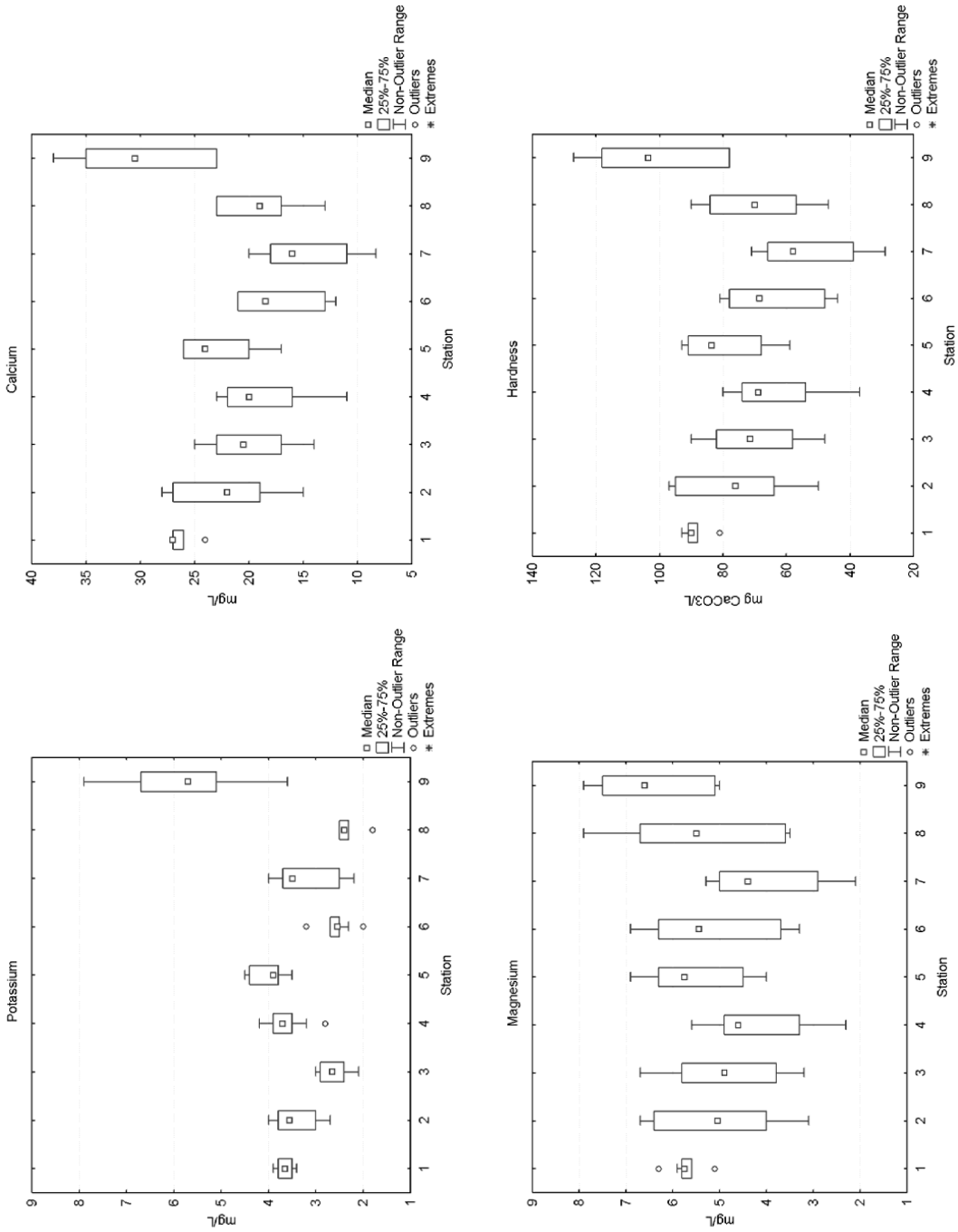


Figure 4. Box plots of ion concentrations. Reporting limit values substituted for non-detects. Br, Fl, and NO₂ not plotted due to high number non-detects (88%, 98%, and 100% non-detects, respectively). Number of samples for each analyte at each station was 10, except for stations 7 (N=9), 8 (N=7), and 9 (N=6).

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

Station 1 is shown in Figure 5. The Massachusetts Department of Environmental Protection (MADEP) Zone II map for Brown's Crossing, Barrows and Salem Street wells is shown in Figure 6. MADEP defines Zone II as "that area of an aquifer which contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at approved yield, with no recharge from precipitation). It is bounded by the groundwater divides which result from pumping the well and by the contact of the aquifer with less permeable materials such as till or bedrock. In some cases, streams or lakes may act as recharge boundaries. In all cases, Zone II shall extend upgradient to its point of intersection with prevailing hydrogeologic boundaries (a groundwater flow divide, a contact with till or bedrock, or a recharge boundary)."

Until recently, the Brown's Crossing Wellfield [EPA ID#3342000-01G] consisted of numerous tubular wells installed in wetland and glacial deposits. Constructed in 1928, it was one of several tubular supplies installed by Whitman and Howard, Inc. in the late 1920s and 1930s in eastern Massachusetts. Over the years, the wellfield has been upgraded to improve pumping capacity and water quality. In 2010, due to falling yields and maintenance problems, new replacement wells were installed next to the pump station. Following preliminary water-quality testing, the new wellfield came online in late March 2011. As before, untreated ground water is pumped to the Sargent Water Treatment Plant where it is combined and blended with water from the nearby Barrows and Salem Street supply wells prior to disinfection and distribution. The Water and Sewer Department anticipates that the upgrade will substantially increase wellfield yield and improve water quality.

The wellfield's geologic setting is similar to many other locations in New England, and consists of unconfined and unconsolidated glacial

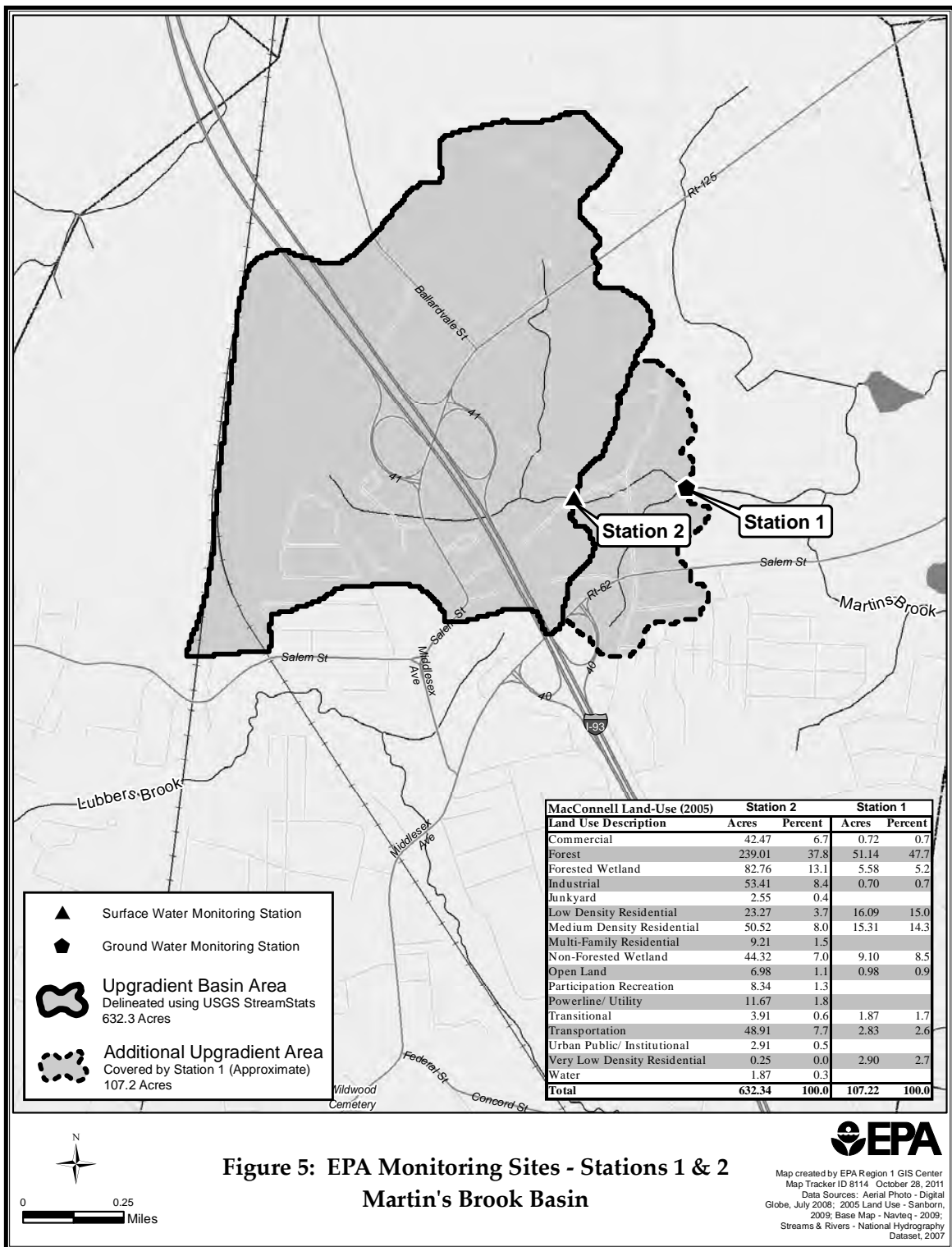
ice-contact deposits underlain by metamorphic bedrock. During the retreat of the Laurentide ice sheet approximately 14,000 to 15,000 years ago, water at first flowed quickly from large masses of melting ice, transporting coarse-grained materials such as boulders, cobbles and gravel into low-lying areas. Over time, this hydraulic energy gradually diminished, and more fine-grained sand, silt and clay were deposited over the coarser-grained deposits. For example, at Brown's Crossing, outwash sediments fill a bedrock trough consisting of 62 feet of well-sorted fine to medium sand over 13 feet of coarse sand and gravel. Well screens range from 61 to 82 feet depth. These basal coarse-grained deposits over bedrock at Brown's Crossing serve as the wellfield's primary water-bearing horizon.

Brown's Crossing is located approximately 2,000 feet northeast of I-93. Because ground water and surface water flow generally from west to east, the water supply is down gradient of several sources of deicing chemicals: I-93 (eight lanes), I-93 interchanges 40 and 41, Ballardville Street, Route 125, Salem Street (Route 62), the Ballardville area commercial office park, and Woburn/Andover Streets. As shown on Figure 5, tributaries containing storm water also flow toward the wellfield from the north, west and southwest.

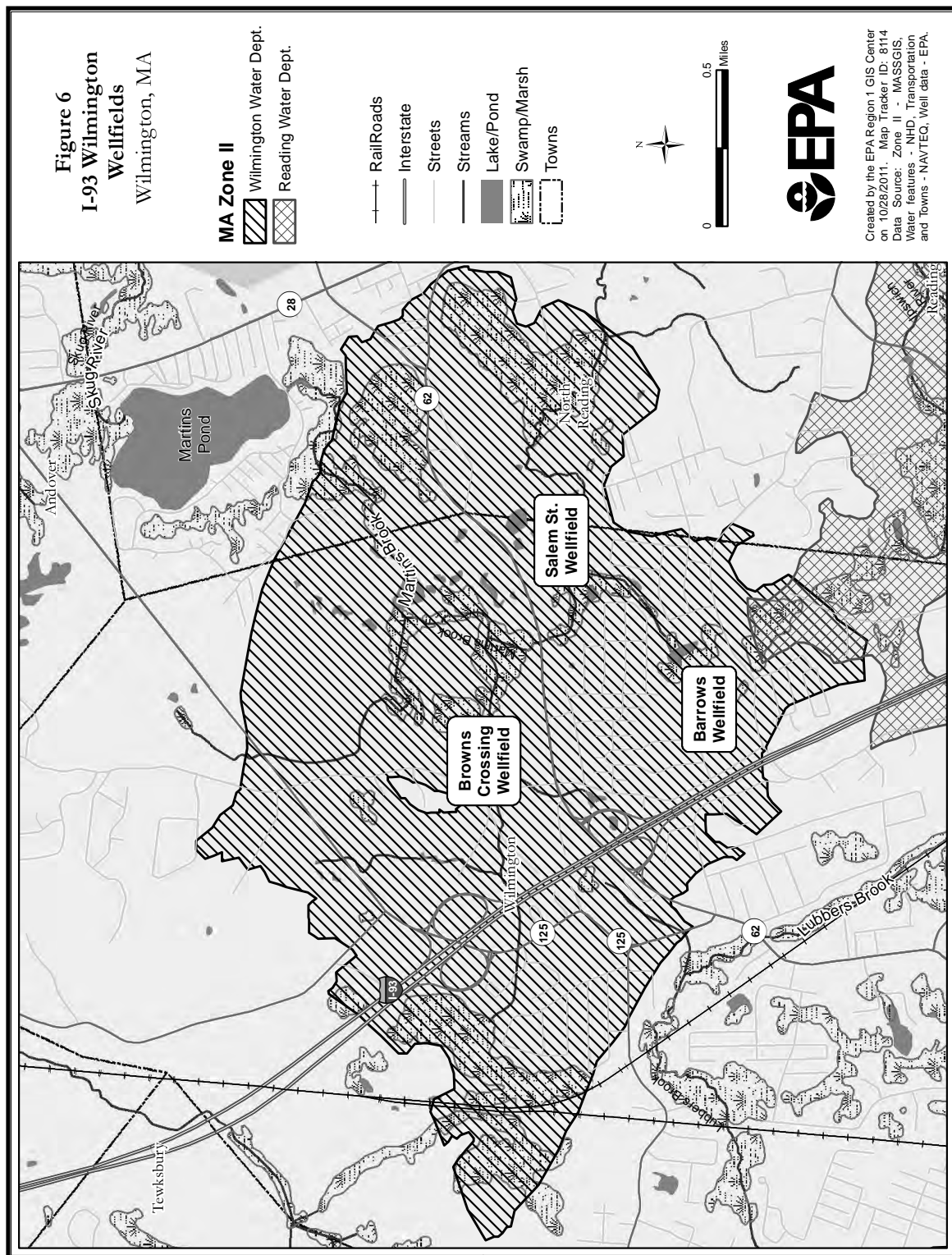
Water Quality Impacts:

In this study, grab samples of untreated water were collected from a source water tap inside the pumping station on nine occasions from December 1, 2009 to April 7, 2010, and transported to the USEPA Regional Laboratory in North Chelmsford, MA for anion/cation analysis. In addition, field measurements of temperature, specific conductivity, pH, TDS and salinity were made onsite.

Available raw water-quality data for chloride over the past 60 years are shown in Figure 7. From 1950 to 1961, chloride concentrations



Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010



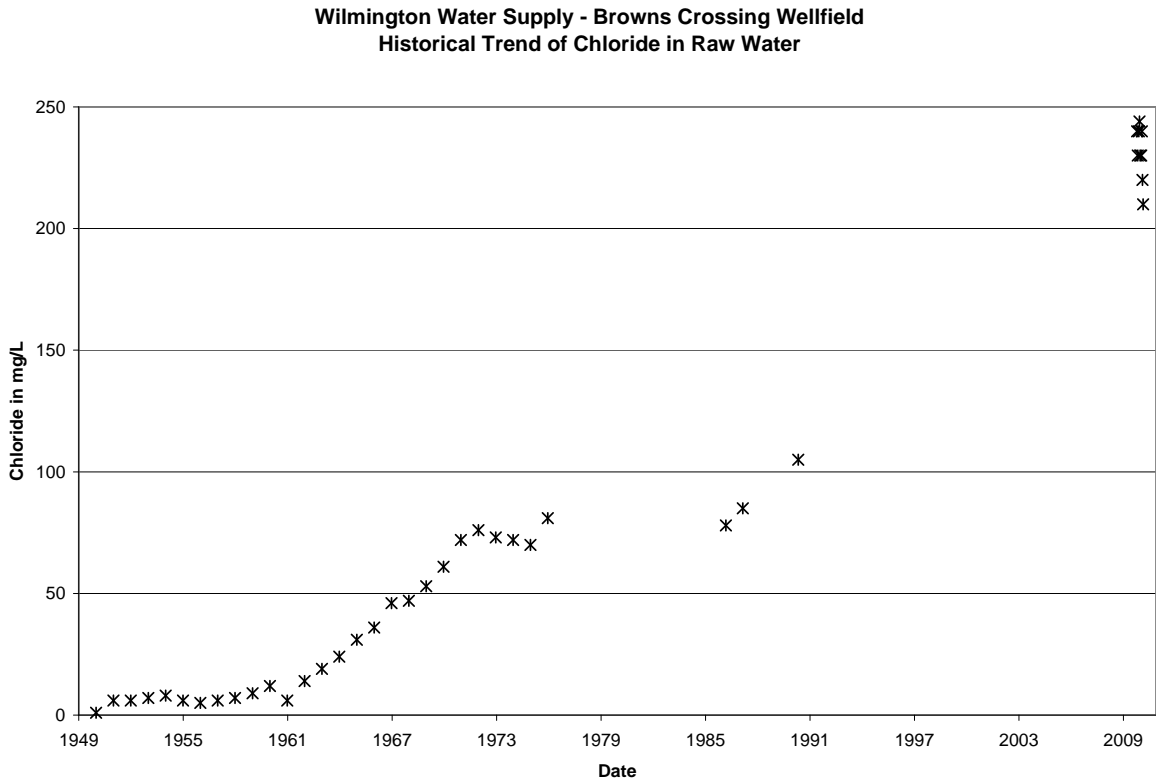


Figure 7: Historical chloride concentrations at Browns Crossing Wellfield (measured in raw water).

averaged less than 10 mg/l. From 1961 to 2010, the trend has been generally upward. Chloride at the wellfield is now more than 20 times that measured before I-93 was opened in 1960. During baseline monitoring over the 2009-2010 winter season, raw water concentrations ranged from 210 to 244 mg/l. If this trend continues, chloride levels will soon exceed the federal secondary maximum contaminant level (SMCL) of 250 mg/l. Monitoring of sodium detected concentrations that range from 110 to 140 mg/l, or 5.5 to 7 times the recommended federal and state advisory level of 20 mg/l in drinking water for those individuals restricted to a total sodium intake of 500 mg/day (EPA Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sodium, Feb 2003, EPA 822-R-03-006).

Station 2: Martins Brook at Andover Street in Wilmington, MA

Geographic Setting and Land Uses:

The watershed of Martins Brook at Andover Street is nearly a square mile in size (632.34 acres), and exhibits multiple and varied land uses that contribute storm water and deicing chemicals to surface and ground water (Figure 5). Over 15% of the land area consists of commercial/industrial development. This is located primarily northeast of I-93 and northwest of Route 125 along Ballardvale Street and Upton Court in Wilmington. Approximately 7.7% of the watershed is made up of major transportation corridors, such as I-93 and the Exit 41 interchange, Route 125 and Ballardvale Street. Low- to medium-density

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

residential neighborhoods southwest of I-93 make up 13% of the land area, and may also contribute to storm water contamination from treatment of secondary roads, driveways and parking lots.

Water Quality Impacts:

Continuous monitoring of specific conductivity from 12/1/09 to 4/7/10 shows that Martins Brook at Andover Street exceeded the 230 mg/l chronic standard for chloride over five discrete intervals totaling 1447.25 hours or 60 days (see Figure 3). The periods ranged in length from 96.75 hours from 12/6/09 to 12/10/09 (with a maximum concentration of 649 mg/l) to 654.5 hours from 12/29/09 to 1/25/10 (with a maximum of 430 mg/l). Chloride in grab samples ranged from 170 to 320 mg/l. No acute exceedances of chloride were detected during the monitoring period.

Stations 3 and 8: Sutton Brook at I-93 in Wilmington, MA

Geographic Setting and Land Uses:

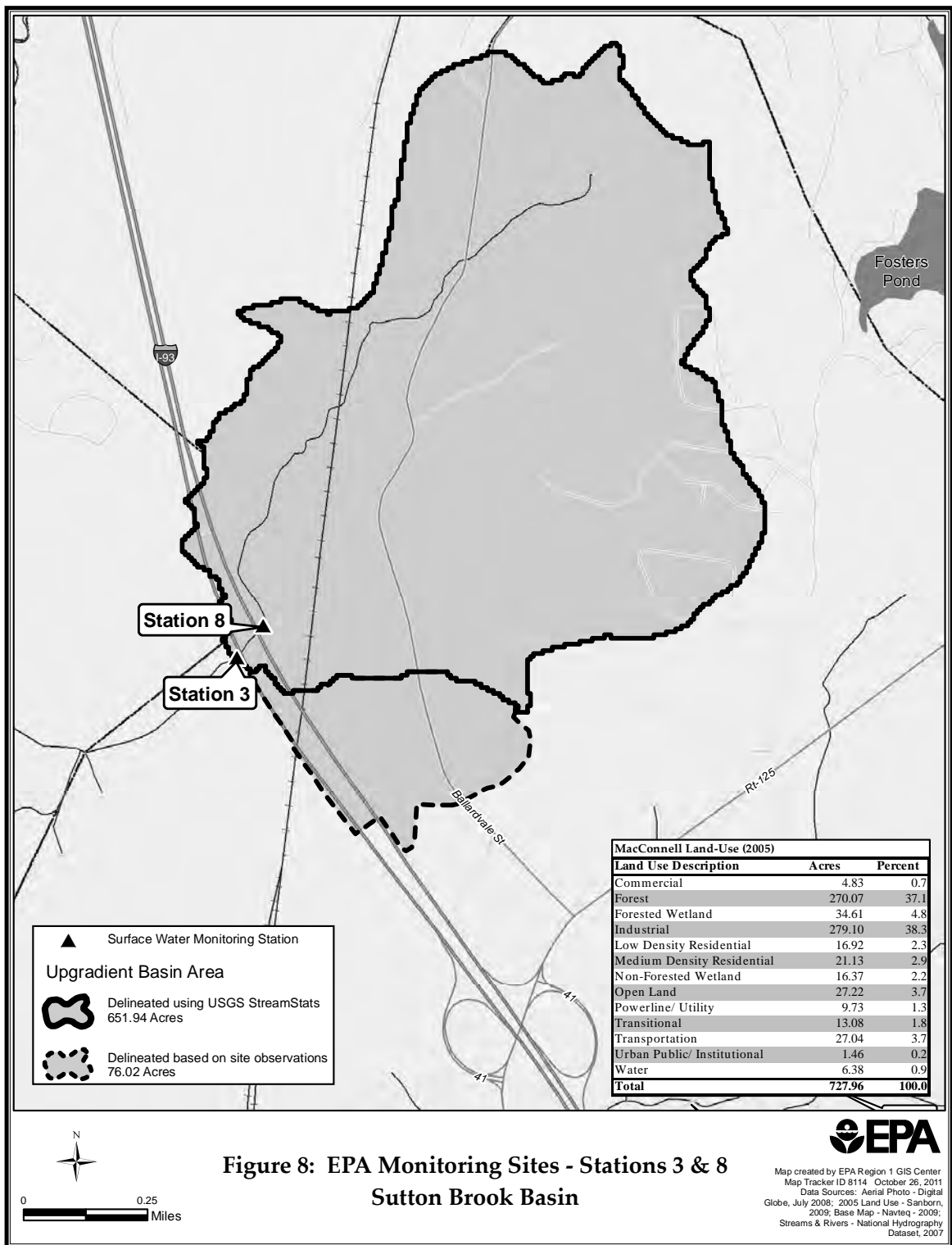
Sutton Brook is a tributary of the Shawsheen River that flows from the northeast to the southwest in a region of low relief between Exits 41 and 42. At I-93, the stream flows through two concrete culverts that are separated by an open median strip covered in vegetation. Upstream of I-93, the watershed's major land uses as mapped in 2005 are characterized as 38% industrial, 37% forest, 27% open land and 27 % transportation (see Figure 8). Its 720 square-mile watershed is the most developed of those monitored in this study, characterized by numerous industrial and commercial companies along Ballardvale Street and Research Drive. Station 3 at the downstream side of the I-93 southbound lane culvert was established on 12/1/09 after previous field visits beginning in April 2009 showed that it was accessible. Station 8 was established later on 12/18/09 immediately upstream of the northbound lane culvert after an additional datasonde became available. Together,

these two sampling locations bracket storm water and deicing chemical impacts from I-93 vs. the rest of the watershed.

Water Quality Impacts:

Continuous monitoring of specific conductivity from 12/1/09 to 4/7/10 shows that Sutton Brook at Station 3 exceeded the 860 mg/l acute standard over three discrete intervals totaling 12.5 hours from early December to early January. The maximum chloride concentration derived from specific conductivity was 1,339 mg/l on January 2, 2010. Despite these acute levels, no chronic exceedances were detected at this location. Chloride in grab samples ranged from 118 to 240 mg/l. Based on datasonde measurements, the average chloride concentration over the four-month period was 154 mg/l..

At Station 8 upstream of I-93, no chronic or acute exceedances were observed. Chloride in grab samples ranged from 88 to 170 mg/l and averaged 125 mg/l based on datasonde records. The I-93 chloride contribution to Sutton Brook that caused acute exceedances last winter may be explained by two factors: 1) MassDOT drainage maps show that there are approximately 38 catch basins connected to 20 outfalls along the I-93 ROW and median strip in the watershed area upstream of Station 3 and downstream of Station 8. These quickly convey salt-laden storm water to grassy shoulders and into the vegetated median strip to the Sutton brook channel; and 2) a large retention pond adjacent to Freihoffer's Bakery and east of the MBTA Haverhill Line drains directly through a culvert under the I-93 northbound lanes into a flowing brook in the median area. This drainage then flows directly northwest to the Sutton Brook channel. The watershed to this pond and the median stream is approximately 68 acres in size, and is highly developed with commercial/ industrial land uses. This significant drainage is therefore a mixture of I-93 and upstream



Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

storm water inputs that will require additional monitoring to characterize. However, the rapid increase of the three acute chloride spikes observed at Station 3 due to this median flow is noteworthy. For example, on December 9, 2009, chloride concentrations rose from 157 mg/l at 12:30 pm to 1,278 mg/l at 2:45 pm in just over two hours.

Station 4: Shawsheen River at I-93 North in Andover, MA

Geographic Setting and Land Uses:

The Shawsheen River is the largest stream monitored in this study. At I-93, its watershed is 39,386 acres or 61.5 square miles in size. The river flows from the southwest to the northeast into the Merrimack River, and includes not only I-93 but portions of I-95 (Route 128), Route 3 and I-495. According to 2005 land-use mapping (Figure 9), approximately 30% of its watershed consists of forest, 9% each of forested wetland and low-density residential, and 18% medium density residential. Transportation makes up about 4% of the land area.

Water Quality Impacts:

Station 4 was located about 450 feet downstream of I-93 near the canoe launch area on Andover conservation land north of Research Drive. Despite the fact that storm water flows from five outfalls connected to 27 catch basins near the I-93 bridge, no chloride exceedances were observed during the four-month monitoring period. The longest period in which chloride concentrations exceeded 230 mg/l began at 5:45 pm on January 20, 2010 and ended at 12:45 pm on January 23, 2010, or less than three days. The maximum reached during this time was 294 mg/l at 12 noon on January 21st. Therefore, the 96-hour criterion was not satisfied. Chloride in nine grab samples ranged from 80 to 190 mg/l, and averaged 128 mg/l based on 12,177 datasonde measurements.

Station 5: Unnamed Tributary to the Shawsheen River at Vale Street in Tewksbury, MA and Station 9: I-93 Storm Water Discharge 1,300 Feet North of Dascomb Road in Andover, MA

Geographic Setting and Land Uses:

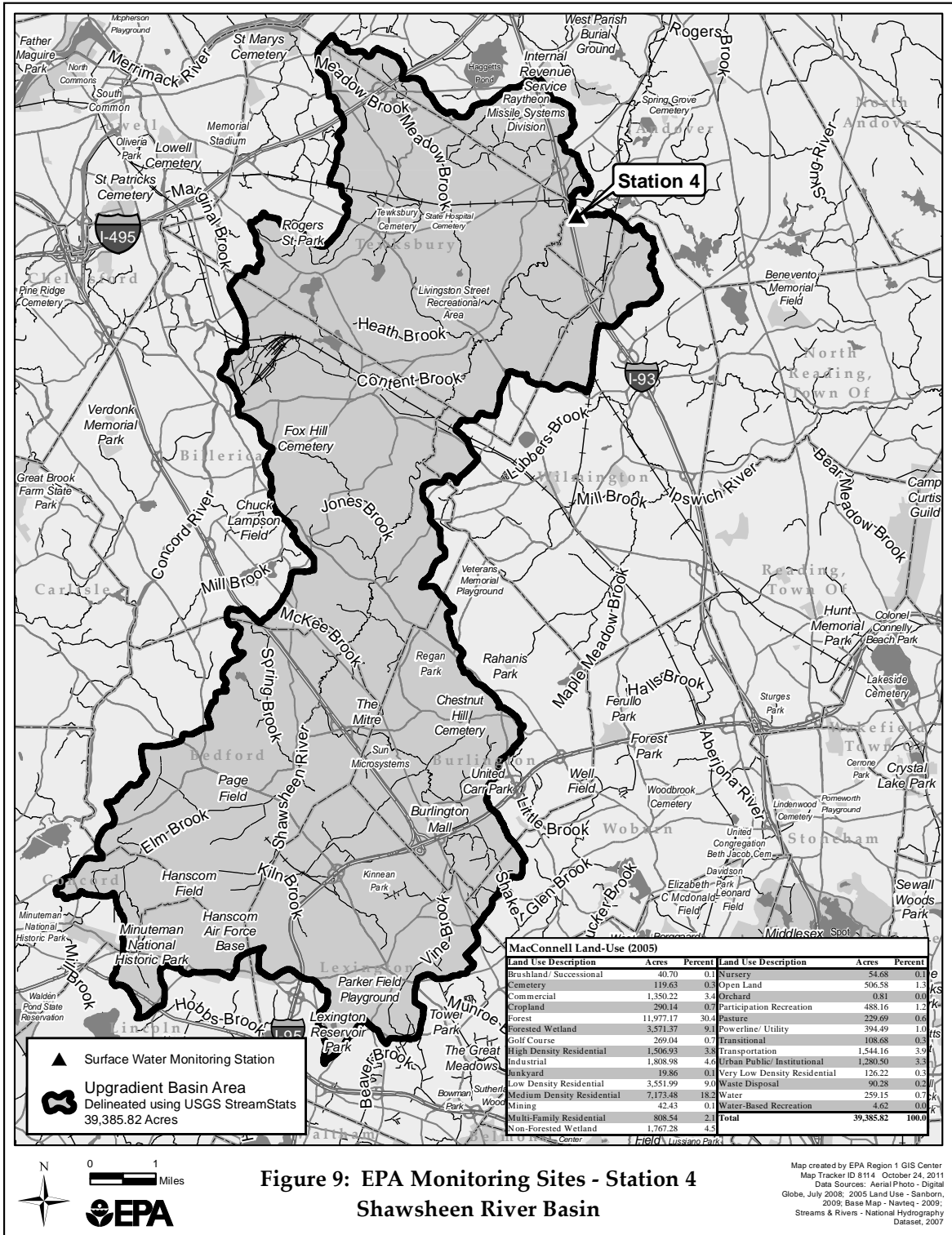
Stations 5 and 9 are located in the watershed of an unnamed tributary to the Shawsheen River. At the Vale Street culvert approximately 285 feet west of I-93 and 860 feet upstream from the Shawsheen River, the tributary drains an area of approximately 407 acres or 0.64 square miles. This watershed includes about 0.95 miles of six lanes of I-93, and the entire Exit 42 Dascomb Road interchange and Park and Ride facility. According to 2005 land-use mapping (Figure 10), the most significant land uses are forest (38.6%), industrial (17.3%), medium-density residential (16.8%), and transportation (8%).

Water Quality Impacts:

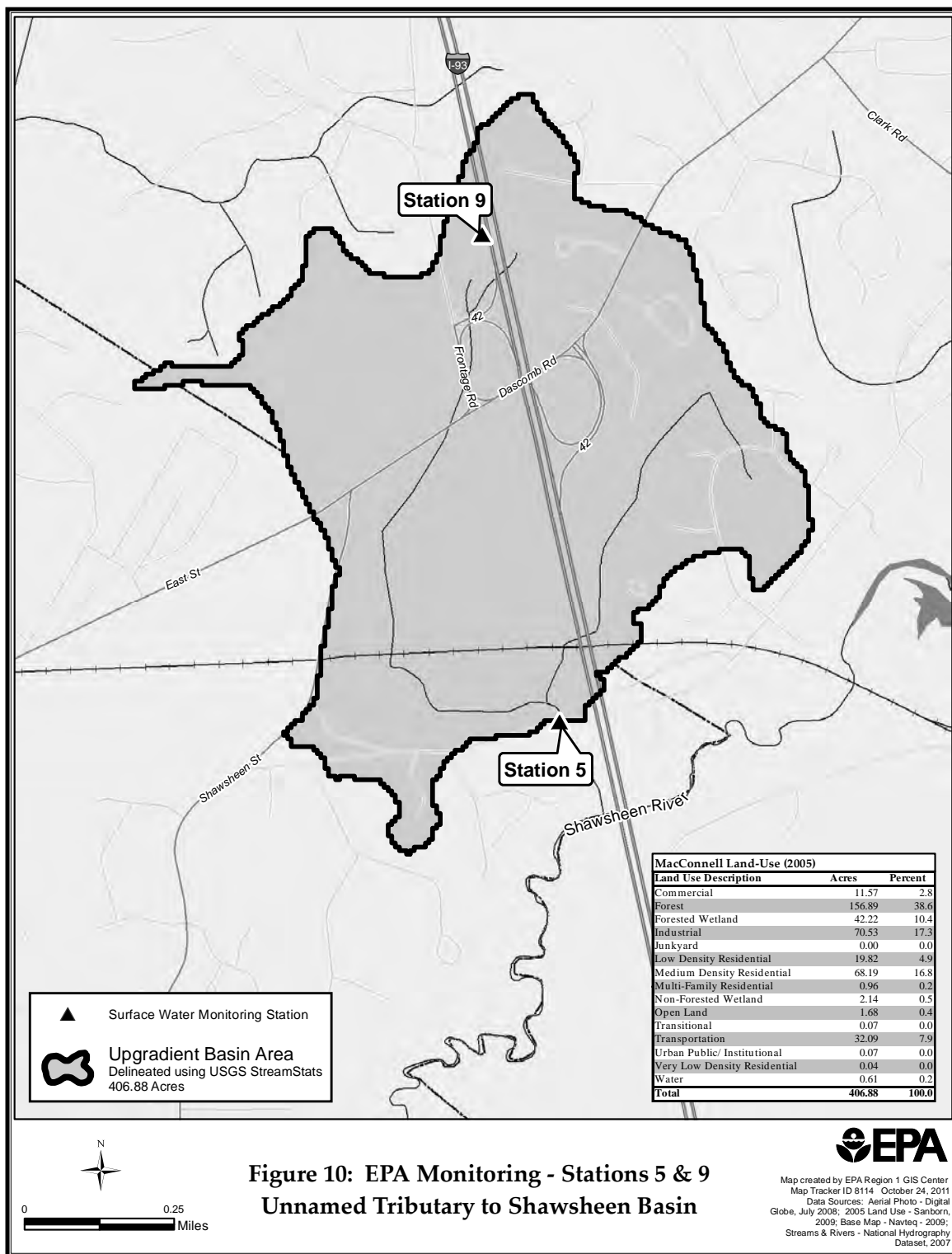
The unnamed Tributary to the Shawsheen River was the stream most impacted by deicing chemical loadings in storm water during the monitoring period. The chronic chloride standard was exceeded during six discrete intervals for a total of 1,298.25 hours or 54 days. The acute standard was exceeded during five intervals for a total of 24 hours, and reached a maximum concentration of 1,346 mg/l on December 6, 2009. Chloride in nine grab samples ranged from 220 to 500 mg/l, and averaged 263 mg/l based on 10,970 datasonde measurements of specific conductivity.

Station 9 was established on February 22, 2010 at a 12-inch diameter outfall that drains into a swale next to the southbound lanes of I-93, approximately 1,300 feet north of Dascomb Road. According to a drainage map provided by MassDOT (Figure 11), this outfall receives only I-93 pavement storm water from 11 catch basins

Douglas Heath and Marcel Belaval



Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010



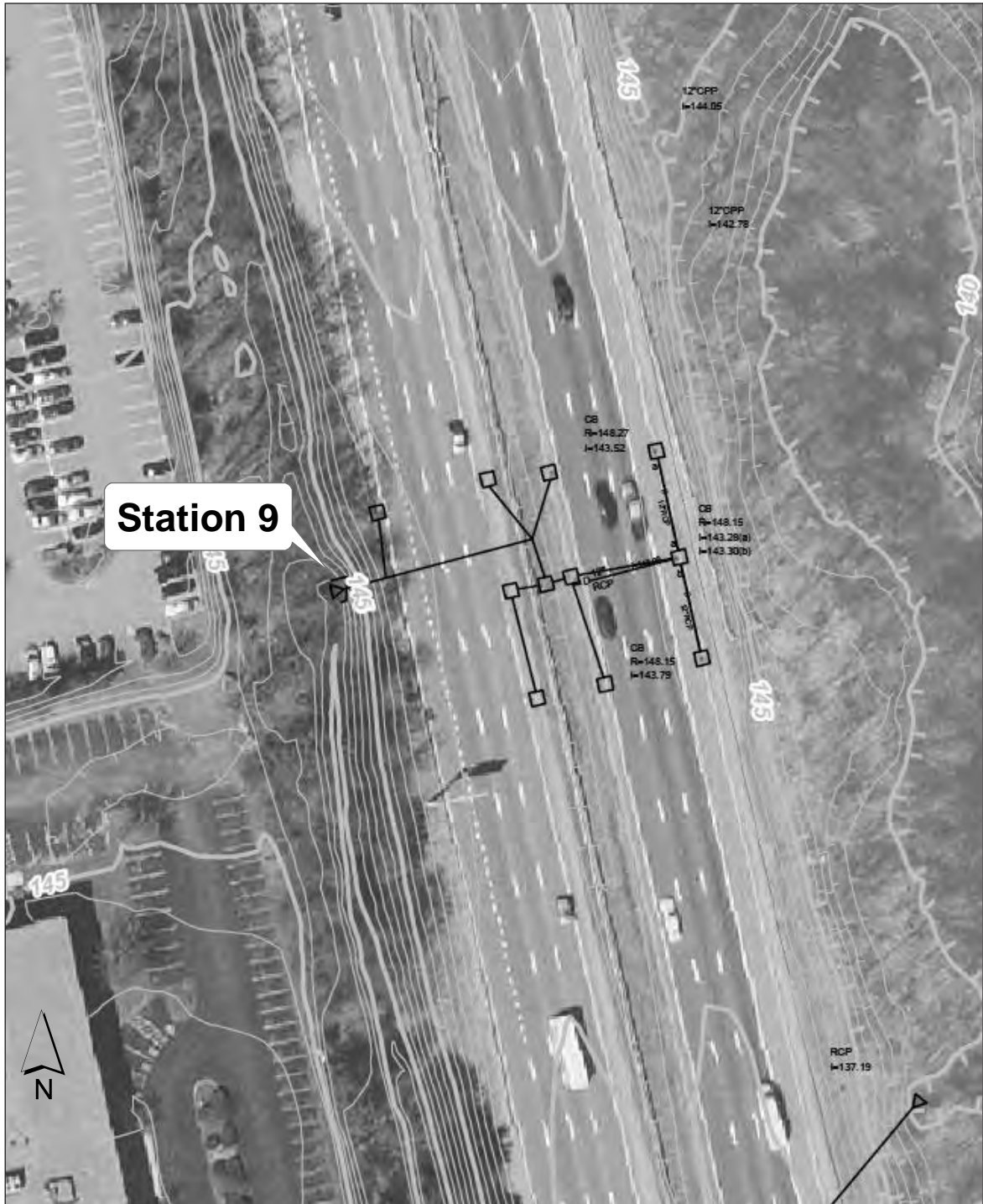


Figure 11: Storm water collection system and outfall at Station 9.
(Source: MassDOT)

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

on both north and south-bound lanes. It therefore represents an excellent location to assess storm-water parameters from pavement drainage during the winter deicing season. A YSI600XLM datasonde was anchored just below the outfall opening and programmed to measure specific conductivity, temperature, TDS and salinity at 15 minute intervals. Water in the swale then flows under the exit and entrance ramps of I-93, the Frontage Road next to the park and ride lot, under Dascomb Road and then south and east towards Vale Street. A few hundred feet north of Vale Street, it meets another tributary that flows southwest under I-93 and also drains a portion of the Exit 42 off-ramps. Chloride concentrations at Station 9 averaged 1,245 mg/l based on 4,207 measurements of specific conductivity. At 2 am on February 24th, it rose to approximately 7,028 mg/l calculated from a specific conductivity of 23,567 uS/cm. Concentrations in three grab samples and duplicates ranged from 730 to 1200 mg/l. According to drainage maps provided by MassDOT, there are approximately 74 catch basins that drain I-93 storm water to 24 outfalls in the watershed.

Station 6: Pinnacle Brook at Frontage Road in Andover, MA

Geographic Setting and Land Uses:

Station 6 is located at the downstream side of the Frontage Road culvert, approximately 350 feet west and downstream of I-93. Pinnacle Brook at this location has a watershed area of 87 acres or 0.14 square miles. The major land uses are medium-density residential (46.7%) and forest (42.4%). Transportation, consisting largely of I-93 and residential roads such as Bridle Path Road and Lovejoy Road, make up 5.7% of the watershed (Figure 12). There are no commercial or industrial uses.

Water Quality Impacts:

Pinnacle Brook had one chronic exceedance lasting 162.5 hours (96.8 days) with a maximum

concentration of 289 mg/l. In addition, three periods of acute exceedances were detected. Together these totaled 12.5 hours in duration with a maximum of 1,339 mg/l on January 20, 2010. Chloride concentrations at Station 6 averaged 186 mg/l based on 10,148 measurements of specific conductivity. Concentrations in grab samples ranged from 130 to 240 mg/l. A MassDOT drainage map shows that I-93 storm water is collected by 16 catch basins that flows directly into Pinnacle Brook upstream of Station 6.

Station 7: Fish Brook at the Abandoned Railroad Grade in Andover, MA

Geographic Setting and Land Uses:

Fish Brook at Station 7 drains an area of 2,587 acres or 4.04 square miles (Figure 13). Major land uses mapped in 2005 are forest (43.7%), low-density residential (13.5%), and forested wetland (10.1%). Transportation, including portions of I-93, the Exit 44 interchange, I-495 and Route 133, makes up 4% of the land area. The largest surface water body is Haggett's Pond which is the principal source of drinking water for Andover, MA. Fish Brook at the abandoned railroad grade culvert receives deicing chemicals from several large highway systems in its watershed, as well as numerous municipal and residential roads. For example, I-495 is 1.5 miles long, I-93 is 1.3 miles and Route 133 is 2.4 miles long in the basin. In addition, one half of Exits 43 and 44 lie in the watershed, as well as the MassDOT Maintenance Facility at Exit 44 where road salt and other deicing compounds are stored and handled. Several tributaries and ground water flow across both I-495 and I-93 to Haggett's Pond, which also receives water from the Merrimack River from the Fish Brook Pumping Station under certain conditions.

Water Quality Impacts:

Fish Brook at Station 7 experienced one chronic exceedance during January 18-25, 2010. This period lasted 162.5 hours or 6.8 days with

Douglas Heath and Marcel Belaval

a maximum chloride concentration of 289 mg/l. The average concentration calculated from 12,182 measurements of specific conductivity was 148 mg/l. Nine grab samples were collected. These ranged from 80 to 260 mg/l for chloride and from 45 to 140 mg/l sodium.

Conclusions:

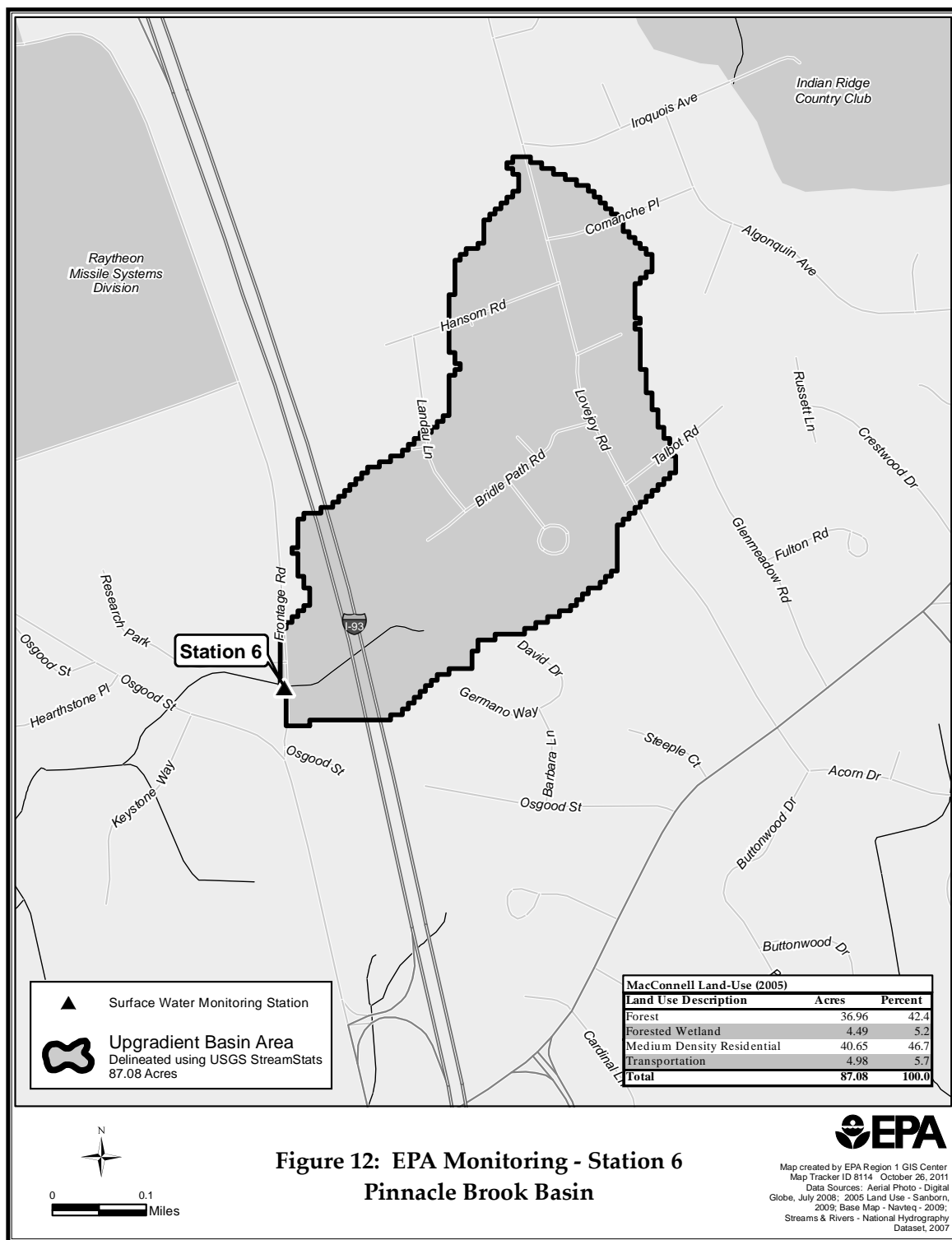
Winter 2009-2010 monitoring of surface and ground water detected 14 chronic and 12 acute exceedances of chloride above EPA's aquatic life standards in five of six perennial streams studied in the I-93 Tri-Town Project Area prior to construction. These are attributed to tons of deicing chemicals applied by state, municipal and private entities. In addition, sodium concentrations in municipal water supplies in Andover and Wilmington were significantly above the federal/state advisory level of 20 mg/l for those individuals restricted to a total sodium intake of 500 mg/day. Monitoring of sodium in raw water at one wellfield for the town of Wilmington detected concentrations that range from 110 to 140 mg/l.

Acknowledgments

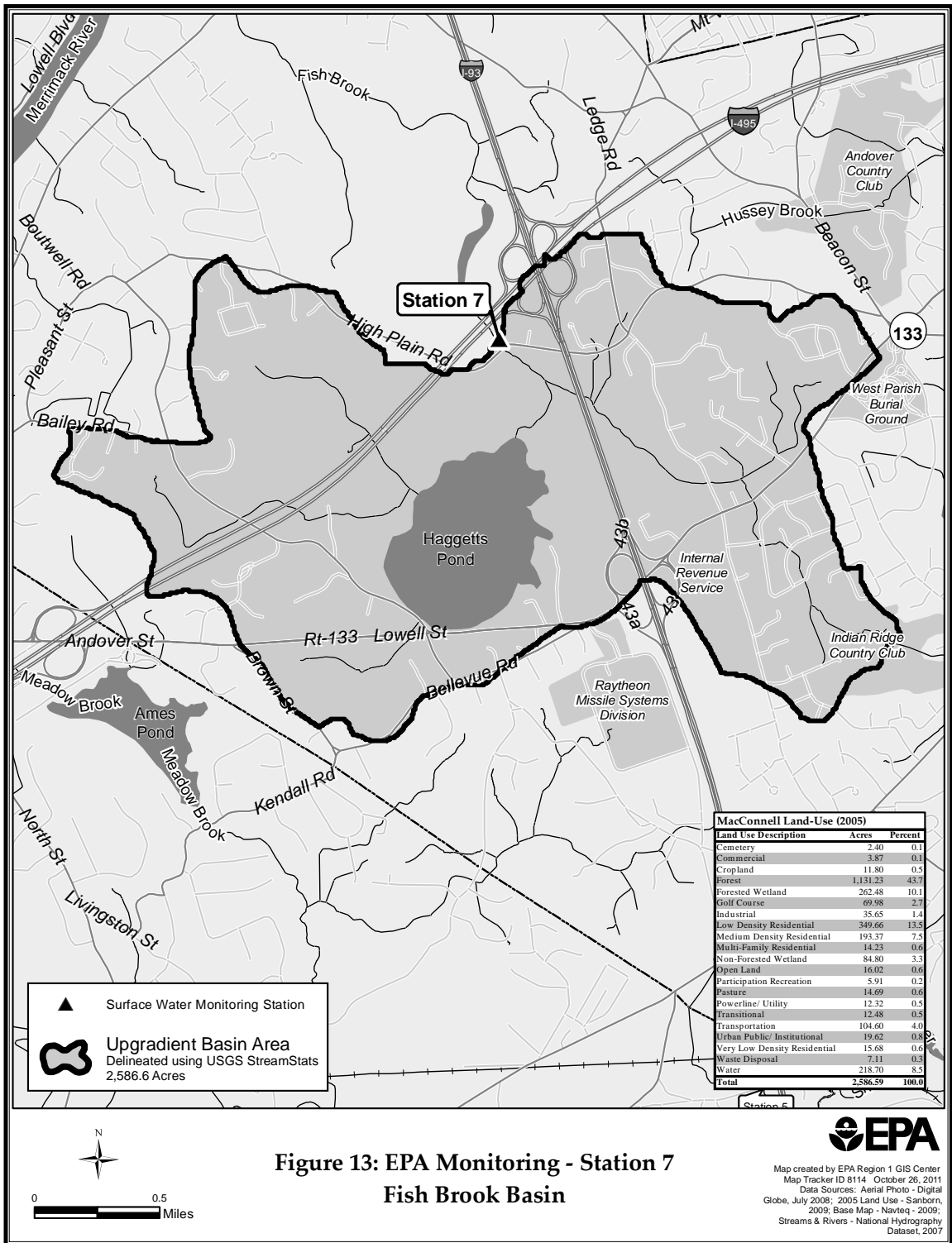
The authors wish to thank the following individuals who provided assistance with this project: Michael Woods, Superintendent of Wilmington's Water and Sewer Department, Cyndi Vaughan, Superintendent of the Andover Water Department, Henry Barbaro of MassDOT, Mark Owen of AECOM, Inc., William Arcieri of VHB, Inc., Professor Rudi Hon and Xiaonan Lu of Boston College, Tom Faber, Charles Porfert, Ted Lavery, Dan Boudreau and Inna Germansderfer of EPA New England, and EPA contractors Doris Guzman and Jori Bonner. In addition, Craig Brown of the U.S. Geological Survey and Timothy Timmermann of EPA New England provided valuable comments for this manuscript.

The findings and conclusions in this report do not necessarily represent the views of the EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010



Douglas Heath and Marcel Belaval



Baseline Assessment of Stream Water Quality in the I-93 Tri-Town Project Area from December 1, 2009 to April 7, 2010

Station	DATE	TIME	Duplicate	FIELD PARAMETERS										LAB RESULTS												
				CAL. STANDARD (uS/cm)	CAL. STANDARD 2 (uS/cm)	CAL. CHECK @ 2.0 (uS/cm)	TEMP (°C)	SPEC COND (uS/cm)	TDS (g/L)	SALINITY (ppt)	PH	HACH kit	Cl	Na	Br	FI	NO3 (mg/L)	NO2 (mg/L)	SO4 (mg/L)	NO3 as N (mg/L)	NO2 as N (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	HARDNESS (mg CaCO3/L)	
1	12/1/2009	9:08		500	500	501	10.43	903	0.587	0.45	231	240	140	ND	ND	4.4	ND	13	0.99	ND	27	5.8	3.9	91		
1	12/1/2009	9:08	D	500	500	501	10.43	903	0.587	0.45	231	240	140	ND	ND	4.4	ND	13	0.99	ND	27	5.8	3.9	92		
1	12/15/2009	9:12		500	500	503	11.39	875	0.569	0.43	5.82	231	230	130	ND	ND	4.8	ND	13	1.10	ND	27	5.6	3.7	90	
1	1/6/2010	9:20		500	500	502	11.08	873	0.566	0.43	6.03	240	130	ND	ND	5.2	ND	13	1.20	ND	26	5.7	3.6	88		
1	1/19/2010	9:51		500	500	501	11.08	878	0.569	0.43	6.12	240	130	ND	ND	5.3	ND	13	1.20	ND	26	5.7	3.6	88		
1	2/2/2010	9:10		500	500	518	11.05	865	0.555	0.42	6.12	230	140	ND	ND	4.8	ND	13	1.10	ND	27	6.3	3.5	93		
1	2/23/2010	9:07		500	500	514	11.05	862	0.560	0.43	6.05	231	230	130	ND	ND	4.4	ND	13	0.98	ND	27	6.3	3.5	91	
1	3/8/2010	9:05		500	500	509	11.02	846	0.550	0.42	6.21	231	240	130	ND	ND	5.4	ND	13	1.20	ND	26	5.6	3.7	89	
1	3/25/2010	9:30		500	500	514	11.02	834	0.542	0.41	6.11	231	240	120	ND	ND	5.9	ND	14	1.3	ND	26	5.6	3.8	88	
1	4/7/2010	9:04		500	500	519	10.75	802	0.521	0.4	6.32	177	210	110	0.13	ND	7.0	ND	16	1.6	ND	24	5.1	3.4	81	
2	4/1/2009	11:25		100	100	101	6.47	1041	0.677	0.52	244															
2	10/2/2009	13:01		100	100	103	12.62	1196	0.777	0.60																
2	12/1/2009	9:24		500	500	501	5.20	898	0.584	0.44																
2	12/8/2009	12:52		500	500	509	3.80	906	0.589	0.44	6.43	231	230	130	ND	ND	1.8	ND	11	0.41	ND	18	4.00	3.00	61	
2	12/15/2009	9:30		500	500	503	3.01	806	0.524	0.39	6.43	231	220	130	ND	ND	1.8	ND	11	0.41	ND	19	4.00	2.90	64	
2	12/16/2009	9:50	D	500	500	507	1.60	1020	0.663	0.50																
2	1/19/2010	9:35		500	500	504	1.63	1062	0.680	0.50	6.17	271	300	170	ND	ND	2.5	ND	15	0.56	ND	28	6.50	4.00	97	
2	1/19/2010	10:10		500	500	502	1.80	1136	0.740	0.56	6.22	331	320	180	ND	ND	2.3	ND	14	0.52	ND	26	6.80	3.80	89	
2	2/2/2010	9:20		500	500	518	1.70	1058	0.687	0.52	6.44	289	300	170	ND	ND	2.8	ND	16	0.63	ND	27	6.70	3.60	95	
2	2/23/2010	9:40		500	500	514	2.80	1079	0.702	0.53	6.38	314	300	170	0.21	ND	2.1	ND	15	0.47	ND	28	6.40	3.60	96	
2	3/5/2010	12:08		500	500	513	4.77	823	0.536	0.40																
2	3/8/2010	9:20		500	500	509	4.72	890	0.579	0.44	6.42	250	280	140	ND	ND	2.2	ND	14	0.50	ND	22	4.80	3.50	75	
2	3/25/2010	9:40		500	500	514	6.67	610	0.396	0.30	6.23	161	170	95	ND	ND	1.7	ND	11	0.38	ND	15	3.1	2.7	50	
2	4/7/2010	9:20		500	500	519	12.00	758	0.493	0.37	6.65	203	200	110	0.12	ND	1.7	ND	14	0.38	ND	21	4.3	3.1	70	
3	4/1/2009	15:30		100	100	103	11.35	497	0.323	0.24																
3	12/1/2009	12:37		500	500	501	5.49	599	0.391	0.29	6.63	104	120	70	ND	ND	1.5	ND	13	0.34	ND	17	4.20	2.40	60	
3	12/8/2009	15:23		500	500	509	2.97	673	0.441	0.33																
3	12/15/2009	12:18		500	500	503	0.23	434	0.313	0.23	6.63	104	120	70	ND	ND	1.3	ND	13	0.43	ND	15	3.40	2.10	51	
3	1/6/2010	12:40		500	500	504	0.86	746	0.481	0.36	6.30	177	180	100	ND	ND	3.5	ND	19	0.79	ND	23	5.70	2.90	81	
3	1/6/2010	12:40	D	500	500	504	0.86	746	0.481	0.36	6.30	177	180	100	ND	ND	3.4	ND	19	0.77	ND	23	5.90	2.90	82	
3	1/19/2010	13:38		500	500	502	0.23	930	0.605	0.45	6.38	221	240	140	ND	ND	2.7	ND	18	0.61	ND	21	5.00	2.90	73	
3	2/2/2010	13:15		500	500	518	0.86	705	0.457	0.34	6.52	171	180	98	ND	ND	4.3	ND	22	0.97	ND	25	6.70	3.00	90	
3	2/23/2010	13:44		500	500	514	2.17	670	0.567	0.42	6.56	161	170	89	ND	ND	2.9	ND	19	0.65	ND	24	5.90	2.80	84	
3	3/5/2010	13:08		500	500	509	6.68	217	0.141	0.10																
3	3/8/2010	12:15		500	500	509	6.29	622	0.406	0.30	6.54	130	160	84	ND	ND	3.2	ND	19	0.72	ND	20	4.80	2.70	70	
3	3/25/2010	12:55		500	500	514	7.95	437	0.283	0.21	6.73	104	120	63	ND	ND	1.9	ND	14	0.43	ND	14	3.2	2.3	48	
3	4/2/2010	12:20		500	500	519	12.89	489	0.384	0.24	6.58	117	120	66	ND	ND	2.0	ND	17	0.45	ND	17	3.8	2.5	58	
4	10/2/2009	15:55		500	500	103	13.47	482	0.314	0.23																
4	12/1/2009	10:54		500	500	501	5.06	433	0.281	0.21	92	110	57	ND	ND	1.8	ND	12	0.41	ND	23	5.6	3.5	80		
4	12/8/2009	13:37		500	500	509	2.48	575	0.374	0.28																
4	12/15/2009	9:58		500	500	503	0.78	490	0.318	0.23	6.81	117	120	72	ND	ND	2.1	ND	12	0.47	ND	16	3.3	3.5	54	
4	1/6/2010	10:14		500	500	504	0.01	714	0.464	0.34	6.64	212	180	110	ND	ND	3.1	ND	16	0.7	ND	22	4.9	4.2	75	
4	1/19/2010	10:50		500	500	502	0.14	735	0.478	0.35	6.79	177	190	100	ND	ND	3.2	ND	16	0.72	ND	20	4.5	4.1	68	
4	2/2/2010	10:09		500	500	518	0.06	596	0.381	0.28	6.98	117	150	87	ND	ND	3.4	ND	17	0.77	ND	20	4.9	3.9	71	
4	2/23/2010	10:10	D	500	500	514	2.45	562	0.43	0.32	6.98	161	170	96	0.14	ND	2.6	ND	16	0.59	ND	22	4.7	3.8	74	
4	3/8/2010	9:45		500	500	509	5.34	509	0.331	0.25	6.8	117	140	76	ND	ND	2.6	ND	15	0.59	ND	17	3.6	3.8	57	
4	3/25/2010	10:05		500	500	514	12.85	425	0.270	0.16	6.96	117	140	76	ND	ND	2.6	ND	15	0.59	ND	17	3.6	3.8	57	
5	4/1/2009	11:58		100	100	101	7.15	415	0.270	0.20	6.77	92	98	56	ND	ND	1.3	ND	13	0.29	ND	15	3.1	3.2	50	
5	4/1/2009	12:58		100	100	101	12.61	1153	0.749	0.57																
5	4/25/2009	11:45		1500	100	101	12.55	1207	0.785	0.61	3.38															
5	5/13/2009	12:45		1500	100	100	13.70	1090	0.798	0.54	2.48															
5	9/22/2009	10:00		1500	100	101	13.20	1151	0.748	0.57																
5	9/22/2009	10:00		1500	100	103	11.65	1068	0.768	0.54																
5	12/1/2009	11:45		500	500	509	5.01	1332	0.735	0.56	2.92	280	160	ND	ND	4.0	ND	19	0.90	ND	23	5.60	3.50			

Douglas Heath and Marcel Belaval

Station	DATE	TIME	Duplicate	FIELD PARAMETERS					LAB RESULTS													HARDNESS (mg/L CaCO ₃ /L)				
				METER	CAL STANDARD (uS/cm)	CAL STANDARD 2 (uS/cm)	CAL CHECK @ 2 (uS/cm)	TEMP (°C)	SPEC COND (uS/cm)	TDS (g/L)	SALINITY (ppt)	PH	HACH kit CI (mg/L)	Cl (mg/L)	Na (mg/L)	Br (mg/L)	FI (mg/L)	NO ₃ (mg/L)	NO ₂ (mg/L)	SO ₄ (mg/L)	NO ₃ as N (mg/L)		Ca (mg/L)	Mg (mg/L)	K (mg/L)	
5	3/25/2010	10:30		YSI 6001.S	10000	500	509	5.55	941	0.612	0.46	6.54	250	270	150	ND	ND	5.4	ND	20	1.20	ND	20	4.90	4.00	70
5	3/25/2010	11:00		YSI 6001.S	10000	500	514	6.77	813	0.529	0.40	6.59	231	220	130	ND	ND	4.3	ND	17	0.97	ND	17	4.0	3.8	59
5	4/7/2010	10:33		YSI 6001.S	10000	500	519	10.21	928	0.603	0.46	6.49	250	250	140	0.14	ND	4.8	ND	19	1.1	ND	20	4.5	3.8	68
6	12/22/2009	14:03		YSI 6001.S	1500	100	103	12.34	772	0.502	0.38															
6	12/12/2009	11:28		YSI 6001.S	10000	500	501	5.91	615	0.400	0.3															
6	12/26/2009	14:32		YSI 6001.S	10000	500	509	4.93	698	0.434	0.32	6.66	130	140	90	ND	ND	3.7	ND	18	0.84	ND	13	3.3	3.2	46
6	12/18/2009	14:39		YSI 6001.S	10000	500	503	6.20	654	0.424	0.35															
6	1/6/2010	11:42		YSI 6001.S	10000	500	504	1.29	740	0.481	0.38	6.31	177	180	110	ND	ND	3.9	ND	19	0.88	ND	19	5.9	2.6	72
6	1/19/2010	12:18		YSI 6001.S	10000	500	502	1.69	936	0.609	0.46	6.67	240	240	140	ND	ND	3.5	ND	20	0.79	ND	19	5.5	2.7	70
6	1/28/2010	9:21		YSI 6001.S	10000	500	507	3.06	865	0.561	0.42															
6	2/22/2010	12:11		YSI 6001.S	10000	500	518	1.61	859	0.559	0.42	6.91	231	230	140	ND	ND	4.3	ND	21	0.97	ND	21	6.9	2.5	81
6	2/23/2010	11:45		YSI 6001.S	10000	500	514	3.77	797	0.258	0.19	6.79	212	220	130	ND	ND	2.8	ND	20	0.63	ND	21	6.3	2.5	78
6	2/26/2010	11:45	D	YSI 6001.S	10000	500	504	4.41	688	0.444	0.33	6.74	212	200	120	ND	ND	3.9	ND	19	0.88	ND	17	5.1	2.7	79
6	3/8/2010	11:30		YSI 6001.S	10000	500	509	6.38	774	0.503	0.38	6.74	212	200	120	ND	ND	3.9	ND	19	0.88	ND	17	5.1	2.7	63
6	3/25/2010	12:01		YSI 6001.S	10000	500	514	1.47	727	0.345	0.26	6.72	117	130	79	ND	ND	3.2	ND	17	0.72	ND	12	3.5	2.3	44
6	4/7/2010	11:35		YSI 6001.S	10000	500	519	11.89	539	0.351	0.26	6.7	123	130	78	ND	ND	3.0	ND	18	0.68	ND	13	3.7	2.0	48
7	12/12/2009	14:03		YSI 6001.S	10000	500	501	4.22	458	0.297	0.22															
7	12/18/2009	14:33		YSI 6001.S	10000	500	503	6.11	575	0.374	0.28	6.66	130	140	85	ND	ND	0.31	ND	11	0.07	ND	16	4.40	2.20	58
7	12/15/2009	11:09		YSI 6001.S	10000	500	507	0.41	607	0.395	0.29															
7	12/18/2009	14:58		YSI 6001.S	10000	500	504	0.15	723	0.470	0.35	6.15	161	190	120	ND	ND	5.80	ND	12	1.30	ND	18	5.00	3.90	66
7	1/6/2010	12:08		YSI 6001.S	10000	500	502	0.12	964	0.625	0.47	6.10	271	260	140	ND	ND	0.57	ND	14	0.11	ND	20	5.10	4.00	71
7	1/19/2010	12:46		YSI 6001.S	10000	500	518	0.55	713	0.464	0.34	6.14	177	190	110	ND	ND	0.80	ND	13	0.18	ND	18	5.30	3.70	67
7	2/2/2010	12:37		YSI 6001.S	10000	500	514	0.47	727	0.413	0.35	6.18	177	190	110	ND	ND	4.20	ND	11	0.95	ND	18	4.60	3.50	64
7	2/23/2010	11:54		YSI 6001.S	10000	500	509	6.73	472	0.307	0.23	6.40	117	130	76	ND	ND	ND	ND	11	ND	ND	11	2.90	3.00	39
7	3/25/2010	12:30		YSI 6001.S	10000	500	514	6.68	306	0.199	0.15	6.74	70	80	45	ND	ND	ND	ND	8.5	ND	ND	8.3	2.1	2.3	29
7	3/25/2010	12:30		YSI 6001.S	10000	500	507	0.52	570	0.326	0.27	6.59	86	88	51	ND	ND	ND	ND	9.0	ND	ND	11	2.6	2.5	38
8	12/18/2009	11:41		YSI 6001.S	10000	500	507	0.25	570	0.371	0.27															
8	1/6/2010	10:43		YSI 6001.S	10000	500	504	0.18	658	0.428	0.31	6.14	177	170	95	ND	ND	ND	ND	19	ND	ND	22	6.7	2.4	83
8	1/19/2010	11:15		YSI 6001.S	10000	500	502	0.26	659	0.428	0.32	6.42	161	170	94	ND	ND	1.2	ND	17	0.27	ND	19	5.5	2.3	70
8	2/2/2010	10:37		YSI 6001.S	10000	500	518	0.21	619	0.402	0.30	6.20	177	160	85	0.11	ND	1.1	ND	20	0.25	ND	23	6.8	2.4	84
8	2/23/2010	10:40		YSI 6001.S	10000	500	514	1.39	590	0.383	0.28	6.50	161	160	85	0.14	0.11	0.8	ND	19	0.18	ND	23	6.5	2.4	84
8	2/26/2010	11:07		YSI 6001.S	10000	500	504	2.04	160	0.101	0.07															
8	3/5/2010	12:52		YSI 6001.S	10000	500	513	4.53	538	0.350	0.26															
8	3/6/2010	10:10		YSI 6001.S	10000	500	509	4.09	544	0.354	0.20	6.51	123	130	65	ND	ND	4.1	ND	19	0.93	ND	19	4.8	2.5	67
8	3/25/2010	10:35		YSI 6001.S	10000	500	514	5.35	402	0.261	0.19	6.76	86	100	53	ND	ND	0.8	ND	14	0.18	ND	13	3.5	1.8	47
8	4/7/2010	10:08		YSI 6001.S	10000	500	519	10.80	412	0.268	0.30	6.69	81	88	47	ND	ND	3.4	ND	18	0.77	ND	17	3.6	2.5	57
9	2/22/2010	13:45		YSI 6001.S	10000	500	507	6.34	3551	2.178	1.75		1101													
9	3/8/2010	11:15		YSI 6001.S	10000	500	513	7.57	5212	3.390	2.82	5.38	1426	1000	620	ND	ND	1.4	ND	22	0.32	ND	35	7.5	6.7	118
9	3/8/2010	11:15	D	YSI 6001.S	10000	500	513	7.57	5212	3.390	2.82	5.38	1426	1200	730	ND	ND	1.4	ND	22	0.32	ND	38	7.9	7.9	127
9	3/25/2010	11:40		YSI 6001.S	10000	500	514	7.37	4400	2.822	2.31	5.67	835	730	430	ND	ND	2.3	ND	17	0.52	ND	23	5.1	3.6	78
9	3/25/2010	11:40	D	YSI 6001.S	10000	500	514	7.37	4400	2.822	2.31	5.67	835	730	430	ND	ND	2.3	ND	17	0.52	ND	23	5.0	5.1	78
9	4/7/2010	11:16		YSI 6001.S	10000	500	519	10.16	5595	3.630	3.04	5.82	1101	930	560	0.32	0.10	1.1	ND	20	0.25	ND	30	6.3	5.7	101
9	4/7/2010	11:16	D	YSI 6001.S	10000	500	519	10.16	5595	3.630	3.04	5.82	1101	860	510	0.31	ND	0.85	ND	19	0.18	ND	31	6.9	5.7	106

Appendix A; Field parameters and lab results.